

Producible Composite Support Structures for High Performance Missiles

Presented by:

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Acknowledgements

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Summary

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- **An All Composite DACS Structural Bulkhead Was Successfully Designed and Built as an Aluminum Replacement**
- **High Strength Fibers and a High Temperature Capable Resin Exceed Performance Requirements**
- **A Producibility Study Was Completed Which Identified Significant Part Design, Tooling and Process Improvements**
- **Selected Producibility Improvements Were Demonstrated and 13 Parts Were Built**
- **Testing Verified High Temperature Performance**



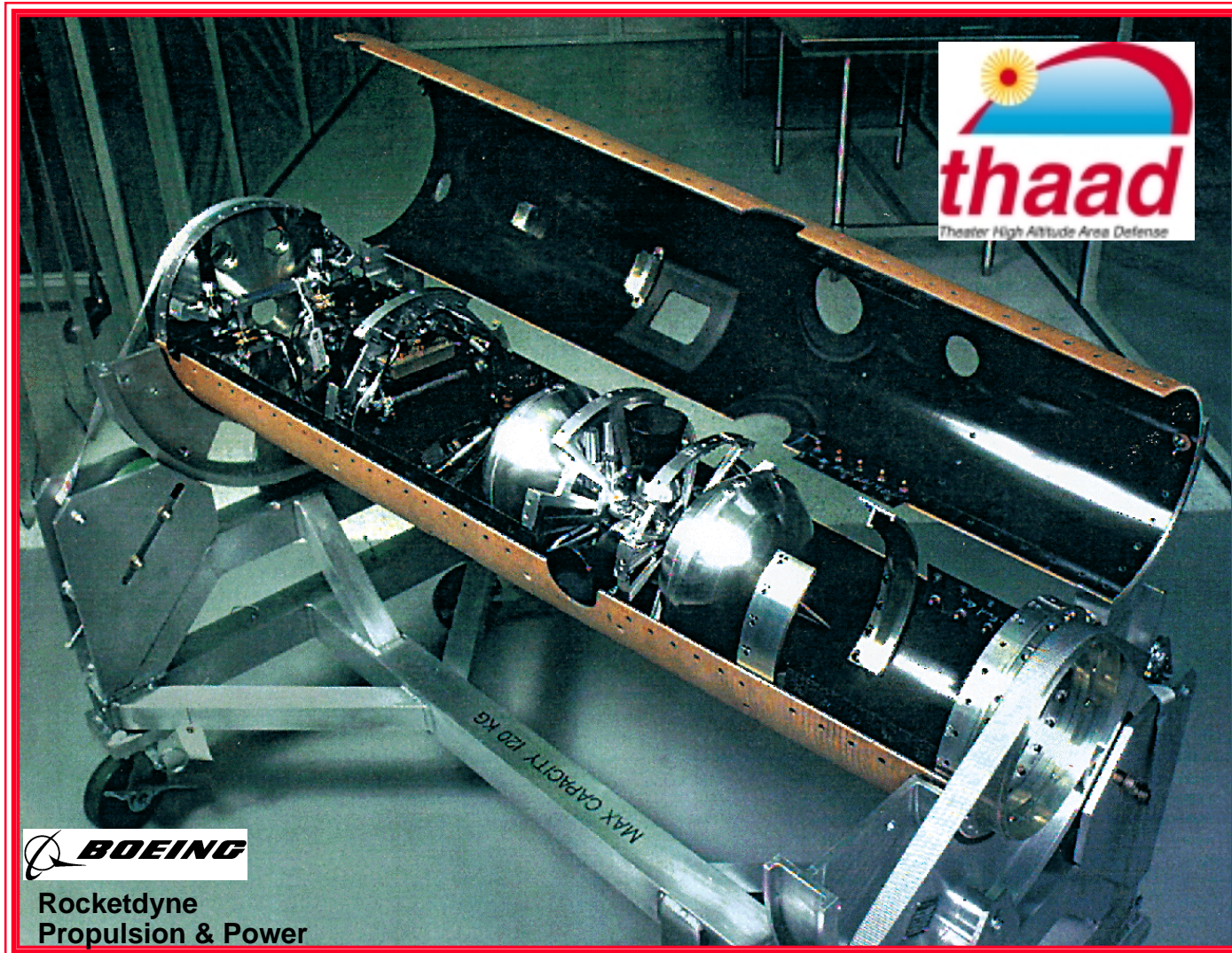
History and Background

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- **In 1994 BMDO and the US Army Research Laboratory Funded a Successful Program to Demonstrate Benefits of Net Molded Composite Bulkhead:**
 - Reduce Weight by >35%
 - Increase Stiffness by ~2X
 - Reduce Cost over Current Aluminum Parts
- **In 1998 BMDO & US Army Space and Missile Defense Command Funded a ManTech Program to:**
 - Improve Manufacturing Process
 - Reduce Manufacturing Costs
 - Evaluate Higher Temperature Application (>500 deg F)
 - Gain Confidence in Production Cost Estimates



THAAD Divert and Attitude Control System

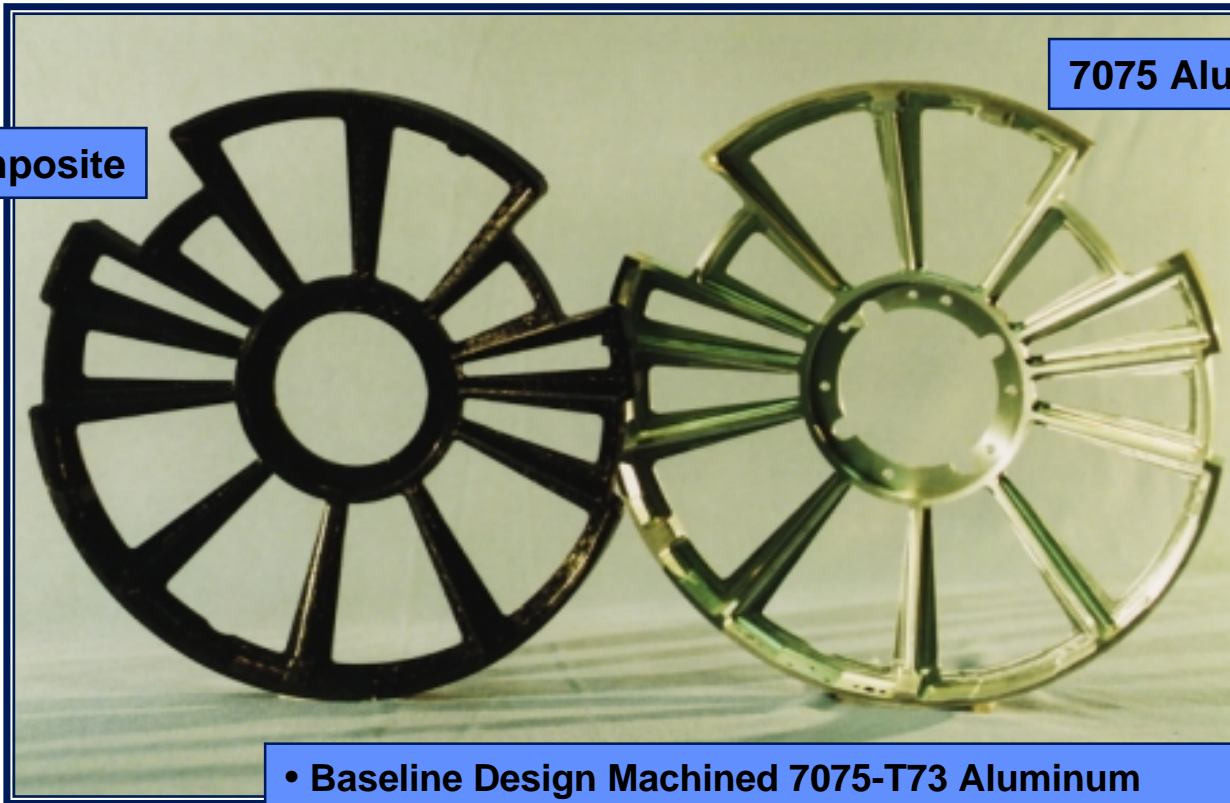


DACS Aft Divert Bulkhead Composite Material Replacement

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Prototype Composite

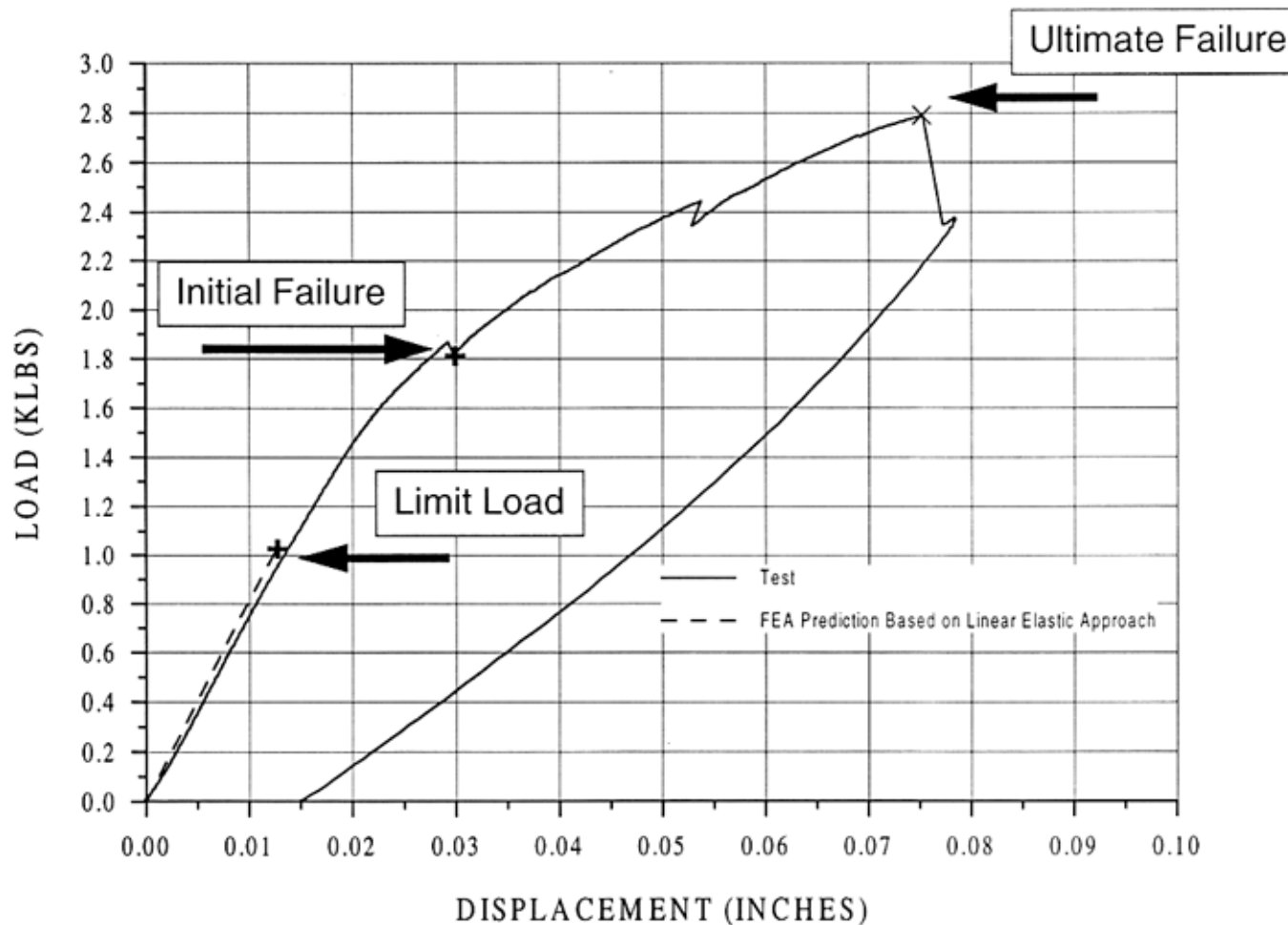
7075 Aluminum



- Baseline Design Machined 7075-T73 Aluminum
- Near Net Shape Compression Molded Composite
- IM7 Composite Exceeds Strength & Stiffness Requirements
- Composite Has >35% Weight Savings Compared to Aluminum
- Composite Projected Lower Production Cost than Aluminum

Prototype Composite Bulkhead Performs Well at 180 deg F

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ManTech Program Accomplishments

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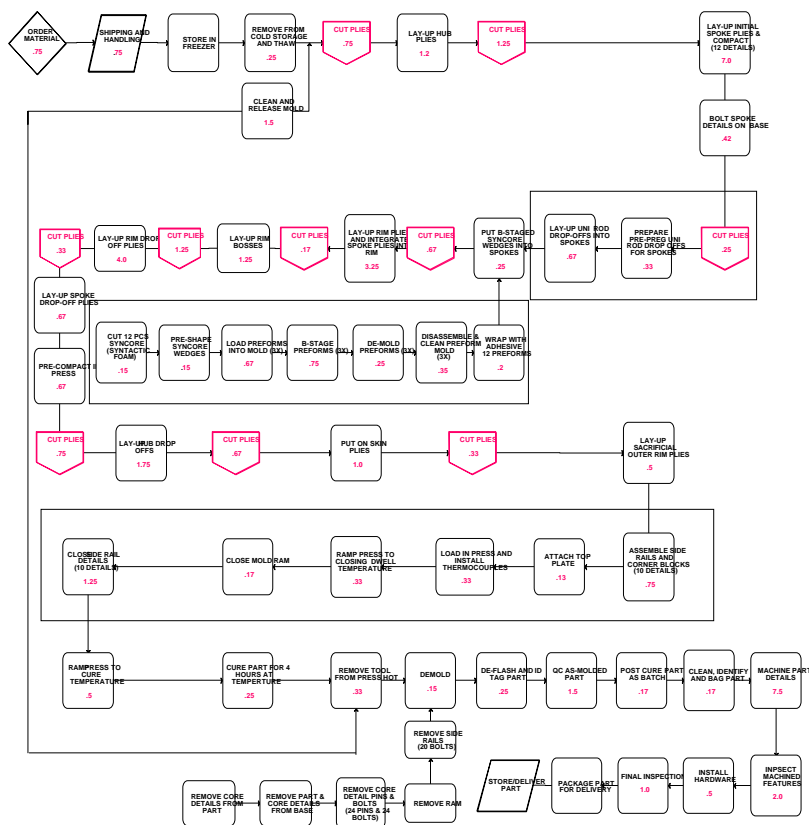
- **Baselined Prototype Manufacturing Process to Select and Measure Producibility Improvements**
- **Demonstrated Selected Improvements in a13 part Build**
 - Improved Part Design in Rib and Rim
 - Simplified Tooling to Improve Mechanization
 - Streamlined Lay-up and Cure Process
- **Quantified Touch Labor Savings**
- **Verified Performance at 500 deg F**



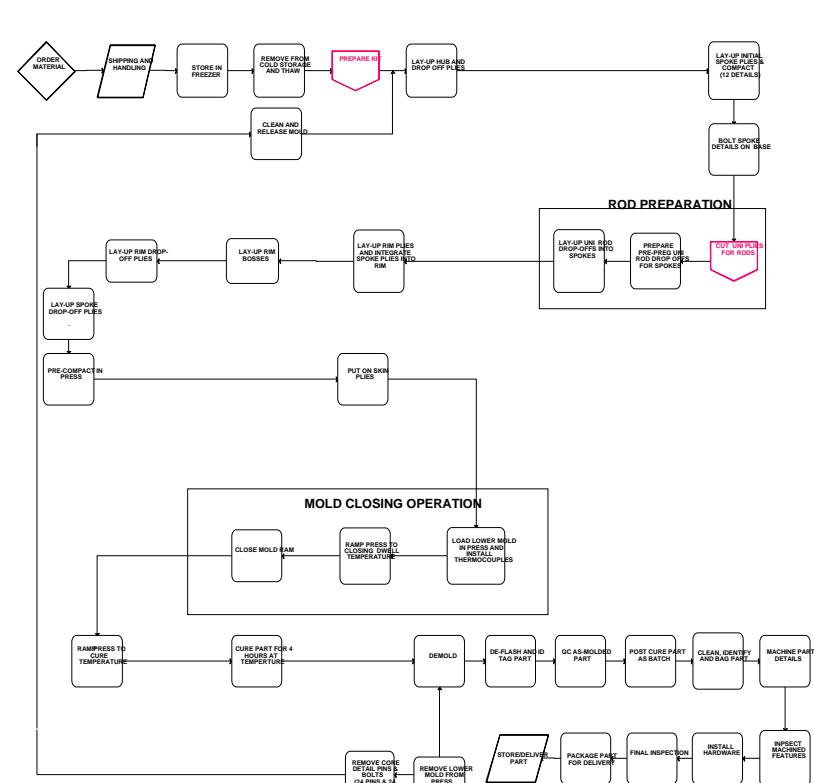
Producibility Evaluation Streamlines Manufacturing Process

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Prototype Process 61 Process Steps



ManTech Process 36 Process Steps



Producibility Evaluation Shows Significant Improvements Achievable

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Process Step	Description	Improvement (%)
Kitting	Preparation of materials into correct size, shape and number	60 - 70
Lay-up	Insertion and fitting of prepared material into mold	60 - 70
Curing	Heating and closing mold, extraction and cleaning	70 – 75
Machining	Post cure machining to add features and meet tolerance	60 – 65
Quality	Inspection QA activities	65 - 70



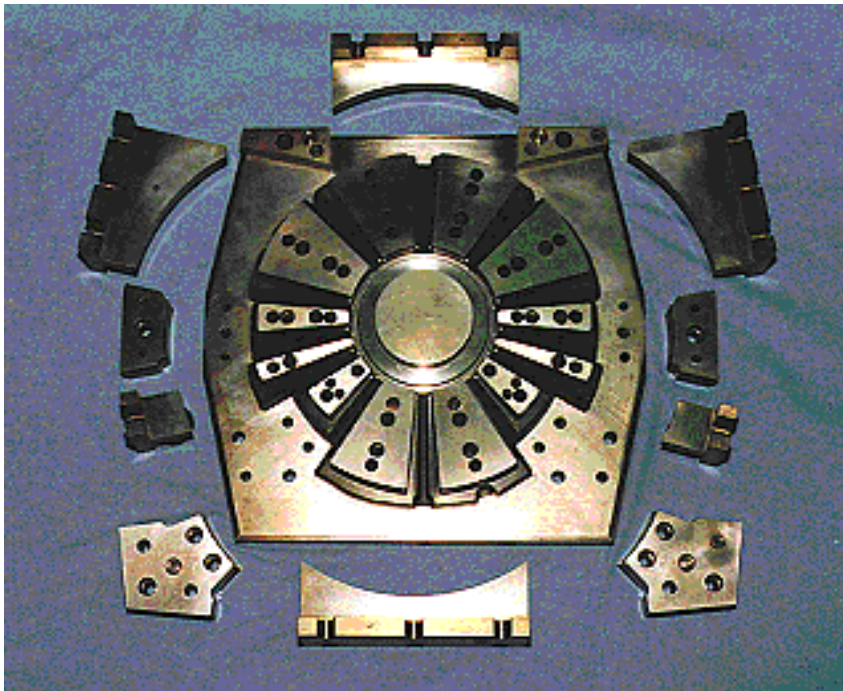
Tooling Improvements



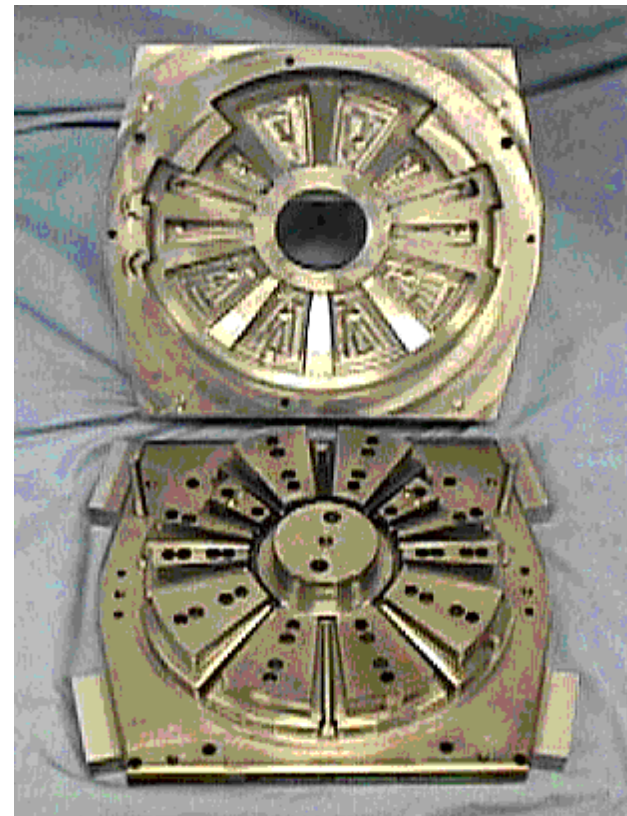
Elimination of Multi-Segment Mold Eliminates > 1 ¼ Hours Per Part

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Prototype Tool



ManTech Tool



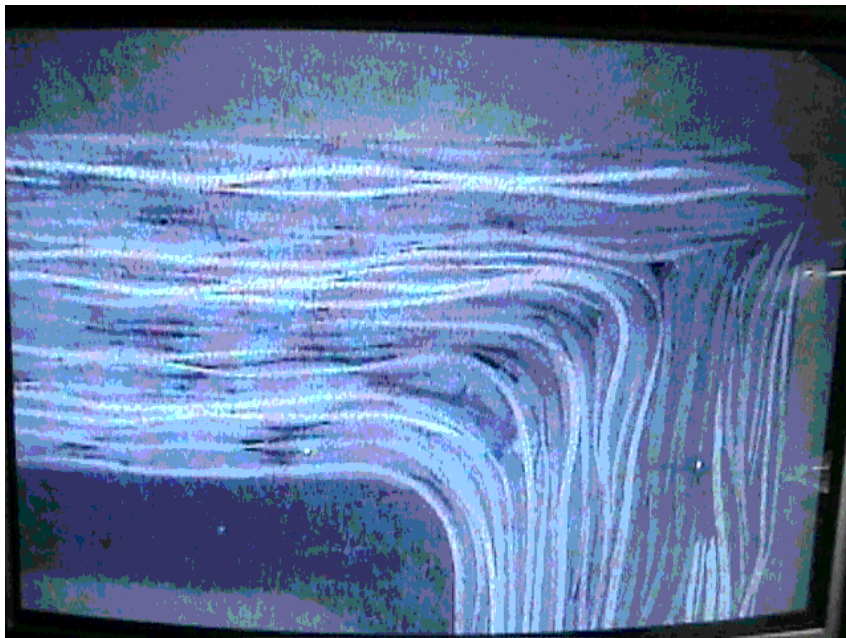
Part Design Improvements



Contoured Outer Rim Provides Better Fiber Alignment and Reduces Weight

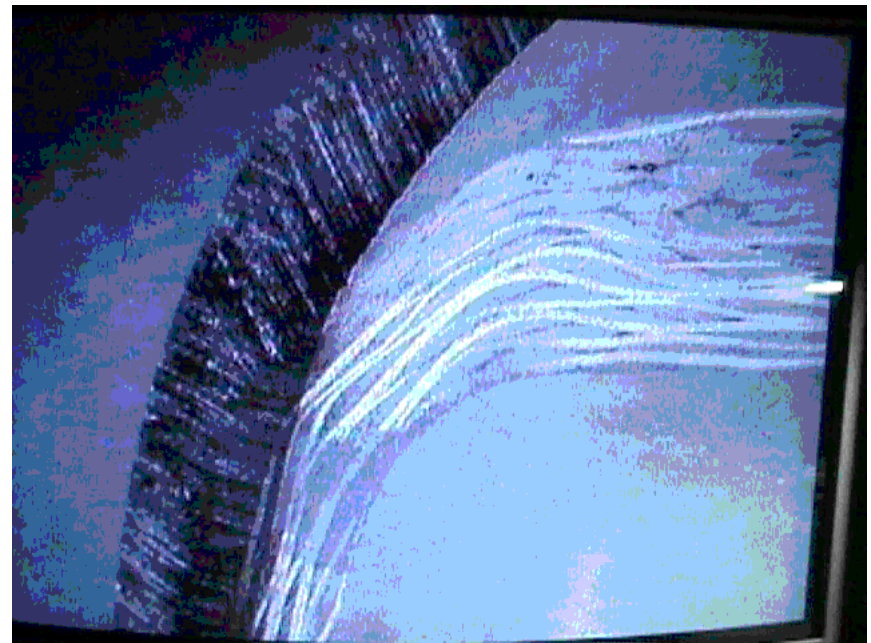
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Prototype Part



Square Outer Rim
Prototype Part

ManTech Part

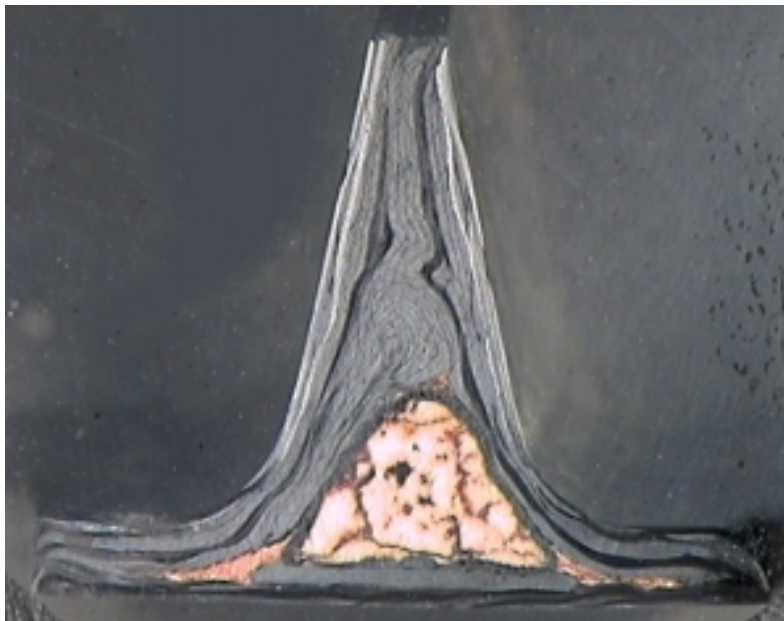


Contoured Outer Rim
ManTech Part

Elimination of Foam Core Reduces Complexity, Improves Quality

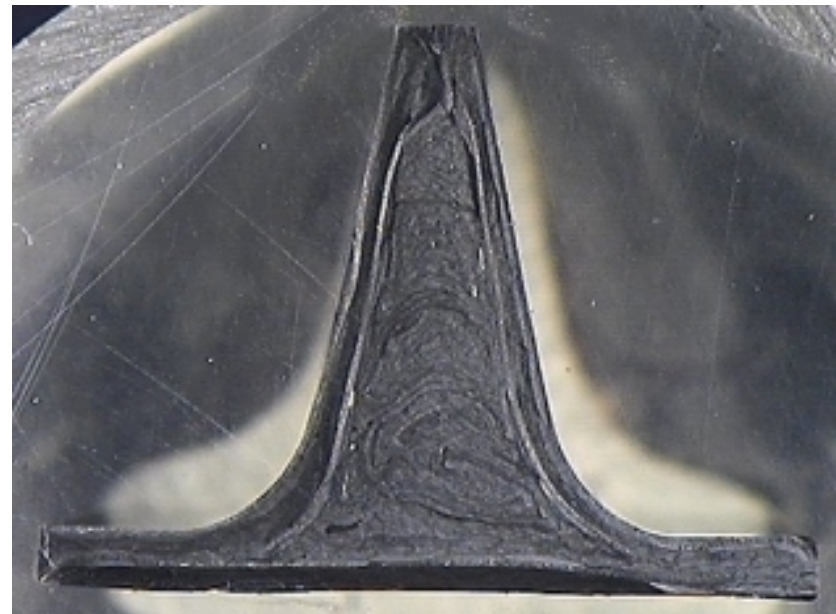
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Prototype Part



Continued Foam Expansion
At Post-Cure Causes
Delaminations

ManTech Part



Solid Uni-Directional
Composite Core Performs Well

Touch Labor Savings



Significant Touch Labor Reductions Measured and 93% Learning Curve Confirmed

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	HOURS	
Process Group	Prototype Process (Part No. 7)	ManTech Process (Part No. 13)
Kitting	6.6	1.3
Lay-up	20.6	7.7
Curing	3.6	0.8
Machining	8.0	3.6
Mold Assembly/ Disassembly	3.8	1.0
QC	4.5	1.5
Other	4.5	2.0
Totals	51.6	17.9



Completed ManTech Part w/Fasteners Ready for Test

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Structural Testing Preliminary Results

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- **Bulkheads Rigidly Fastened per Dwg Requirements**
- **Room Temperature Tension and Compression Tests**
 - Exceeded Design Limit Load by Factor of 3 in Tension
 - Exceeded Design Limit Load by Factor of 4 in Compression
 - Multiple Ribs Provided Redundant Load Paths
- **Elevated Temperature Tension and Compression Tests**
 - Approximate 10% Drop in Ultimate Load over Room Temperature tests
 - Failure Mode same as Room Temperature Tests
 - No failure at Fasteners – No Hole Elongation or Fracturing



Summary

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- **Developed Improved Manufacturing Process**
- **Demonstrated Key Mold Mechanization Steps**
- **Measured Touch Labor Improvements**
- **Preliminary Test Results Indicated Bulkhead Can Function at >500 deg F**
 - **Suggests Potential for Substitution of Lower Cost Material**
 - **Potential to Eliminate Thermal Barrier Component**
 - **Potential Significant Additional DACS System Cost Savings**

